Scenarios and challenges for feeding the world in 2050

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World Bank BBL, Washington D.C., 21 September 2010

The foresight exercise Agrimonde *(introduction)*

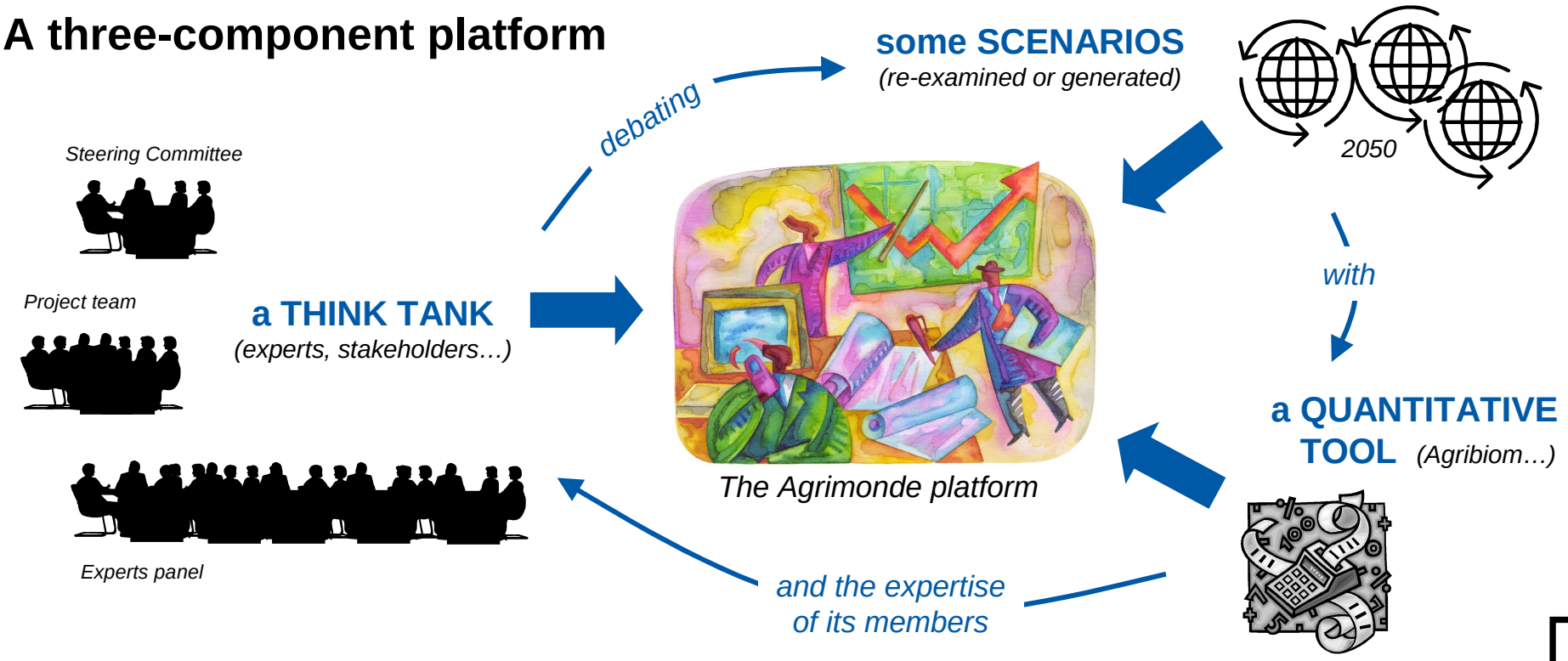
A joint INRA-CIRAD project *(2006-2009 = 1st phase)*

- French National Institute for Agricultural Research (www.inra.fr)
- French Agricultural Research Centre for International Development (www.cirad.fr)

Objectives

(1) to explore possible futures of food and farming systems up to 2050
(2) to design and debate orientations and strategies for INRA - CIRAD research agendas
(3) to contribute to international debates on food, agriculture and the environment

A three-component platform



Part I

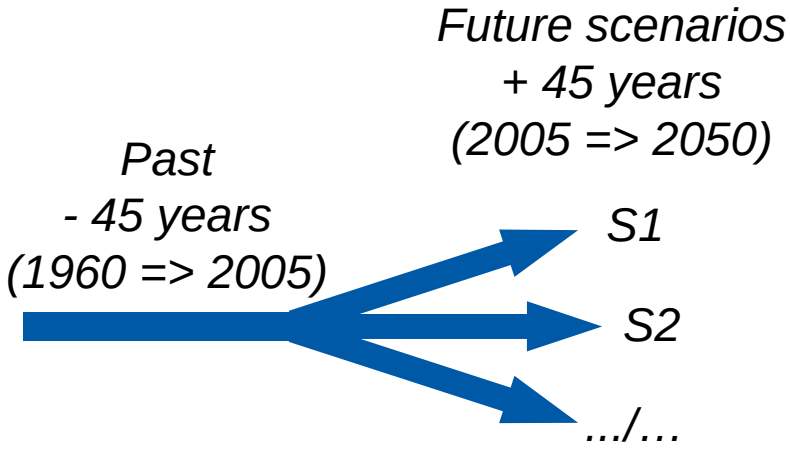
Aims & architecture of Agribiom

A quantitative tool designed for exploring
past and future world production, consumption & trade of biomasses
through (1) collective expertise & debates
(2) hybrid modeling works

❶ The ambition for Agrimonde

Having a quantitative tool for :

(1) revisiting the past,
better understand it *(with new estimates, new models…)*



(2) debating the future
...from scenarios description *(own or external qualitative conjectures)*

translated / summarized into few quantitative parameters *(populations, diets, non-food uses land uses, productivities…)*

Global Consistency ?
(physical equilibrium between biomass uses & resources)

Implications ? *(international trade, energy & water consumptions…)*

Impact of variants ?
(populations, composition of diets…)

❷ The basic engine

Regional S/U balances of food biomasses
reconstituted (1961-2003, using FAO commodity balances in tons)
and/or simulated (2030, 2050…)
for more than 97% of the world land surfaces (149 regions)

Food biomass SUPPLIES

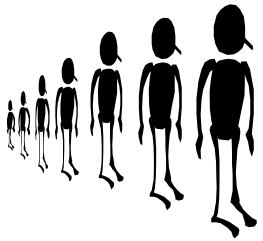
Food biomass USES

land & aquatic SPACES

crops, pastures…

rivers, oceans…

human POPULATIONS

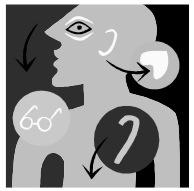


Rural
Urban…

PRODUCTIVITY

in calories
- vegetal
- aquatic
per hectare

FOOD intakes



in calories
- vegetal
- animal
- aquatic
per capita

Exports - Imports

SEED *FEED*

Non-Food Uses (biofuels…)

WASTES

Food PRODUCTION

Food CONSUMPTION

co-products (straw…)
"free" spaces

non-food productions/potentials

environmental impacts

needs +/- satisfied

❸ The unit of account

Food CALORIES
(or equivalent for oilcakes, molasses…)

Total Calories = Carbohydrates (4 kcal/g)
+ Proteins (4 kcal/g)
+ Fat (9 kcal/g)

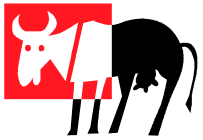
❹ The items

All primary foodstuffs *1961-2003: 120 product lines of FAO Commodity Balances (SUA)*

gathered into 5 « compartments » of food biomasses

PLANTS (VEGE)

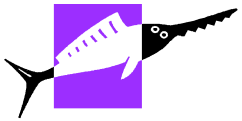
Cereals : wheat, rice, barley, maize…
Sugar crops : sugarcane, sugar beat…
Pulses : beans, peas…
Oilseeds : soybean, groundnut, coconut…
Roots & tubers : cassava, potato…
Fruits & vegetables : apple, onion…
Stimulants : cocoa, coffee, alcohol…



GRAZING ANIMALS (RUMI)
Meats : bovines, goat, mutton…
Milk, Butter, Animal fats…

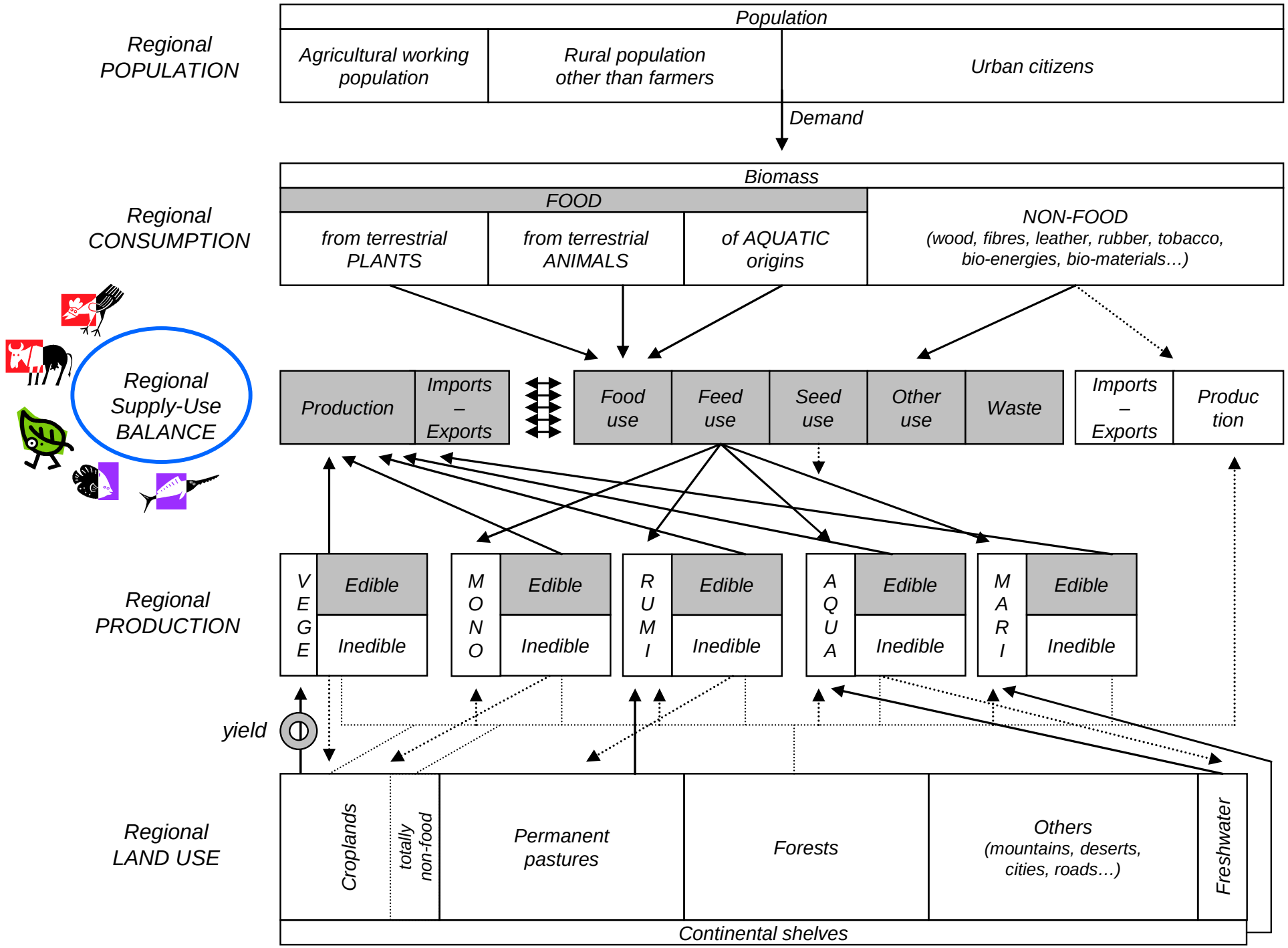
Non-GRAZING ANIMALS (MONO)
Meats : poultry, pig…
Eggs…

FRESH WATER (AQUA)
Fishes…

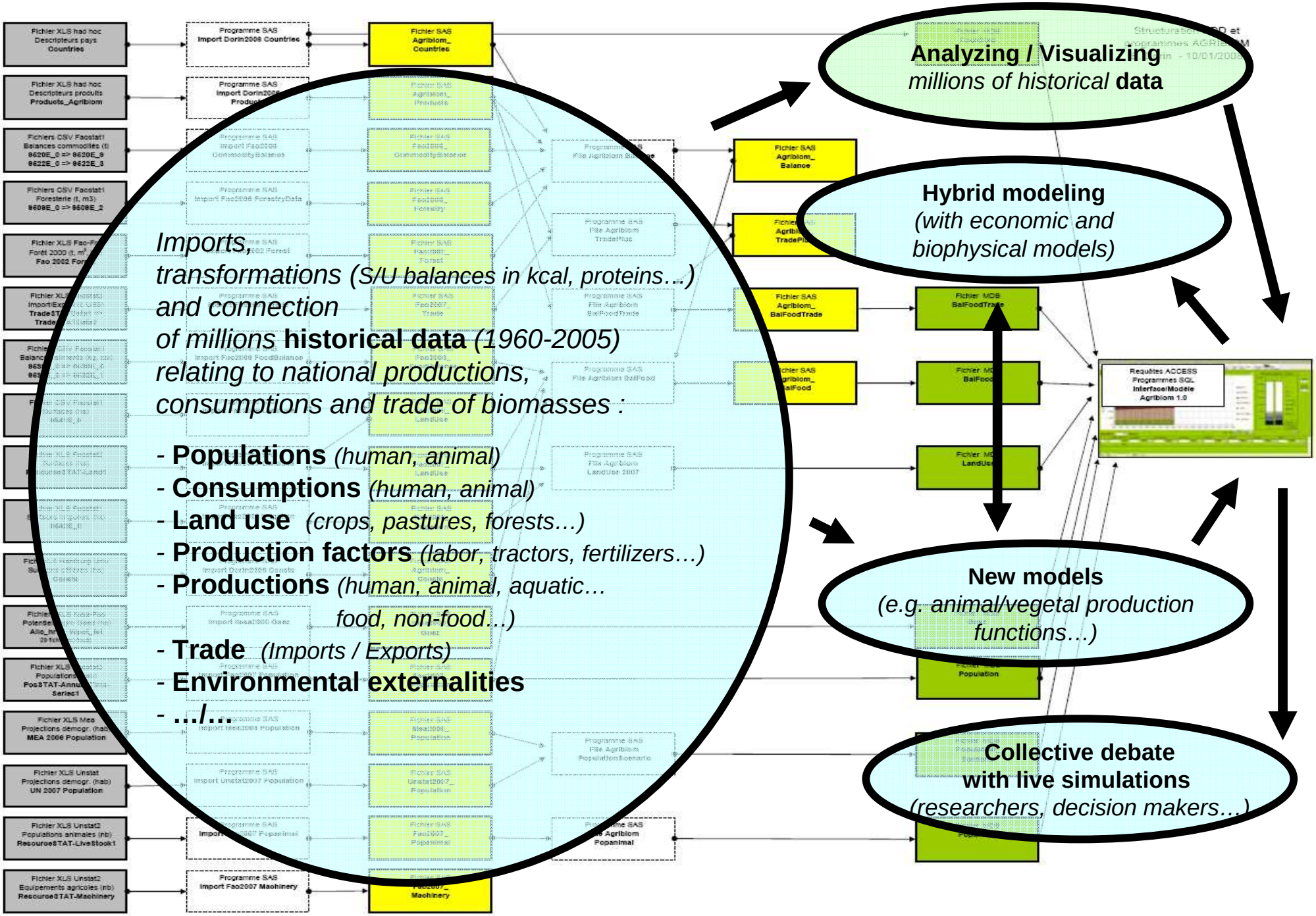


MARINE (MARI)
Demersal & Pelagic fishes… Fats…

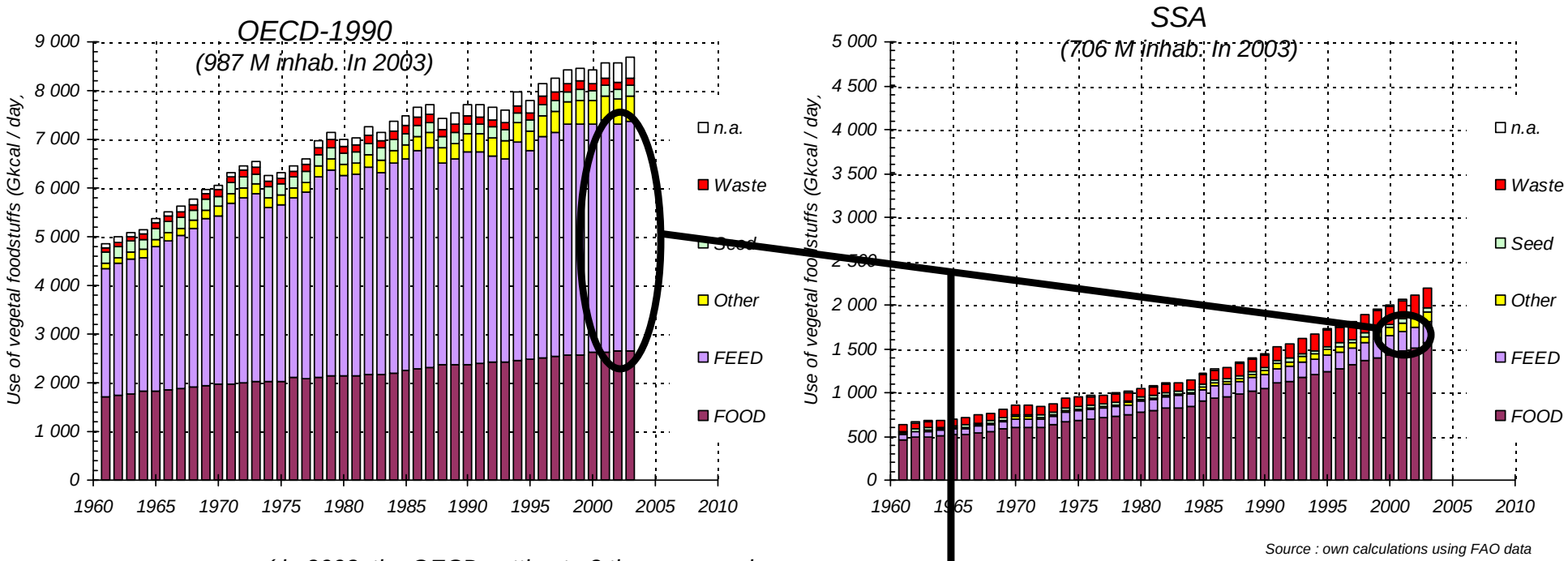
Overview of the AGRIBIOM biomass balance model



❺ An interactive interface



⑥ A statistical model for livestock production



(in 2003, the OECD cattle ate 3 times as much food as the SSA human population did)

RUMI production (meat & milk proteins)
MONO production (meat & eggs proteins)
= f (*FEED*, *PASTURE*, *MONO/RUMI*)

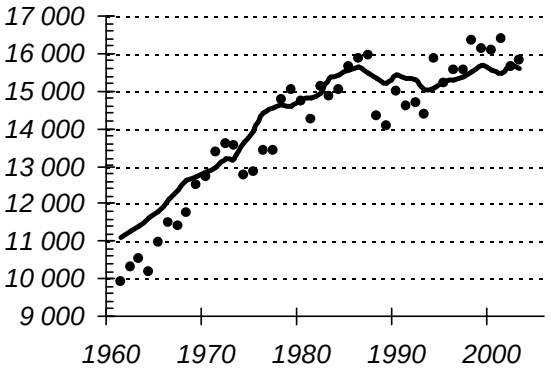
Cross-country animal production functions

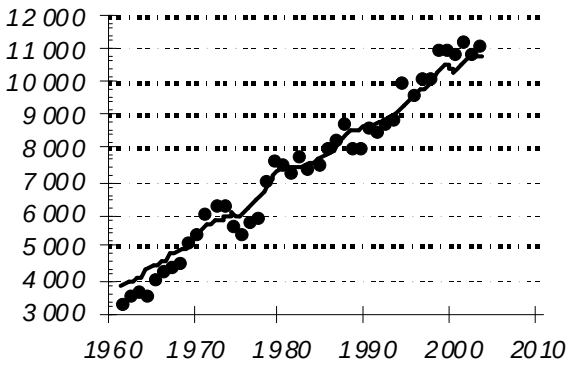
- *Results :*
  - *replicate very-well the past 40-year of national/regional/global animal productions*
  - *“on-line” tests and modeling (choice of model, change of parameters/coefficients, simulations…)*

RUMI
production of proteins (Gg / year)

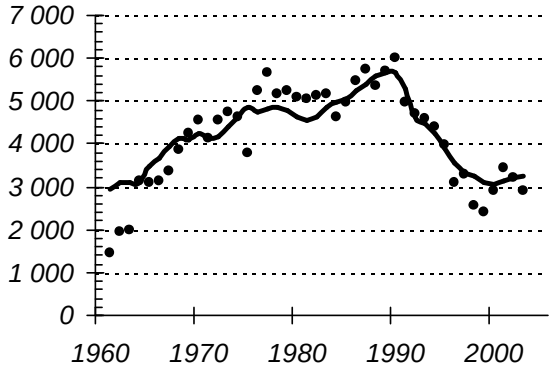
MONO
production of proteins (Gg / year)

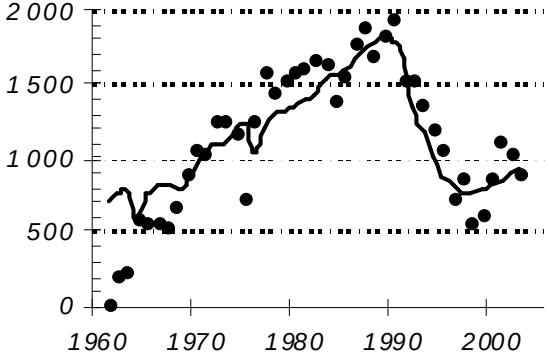
OECD-90



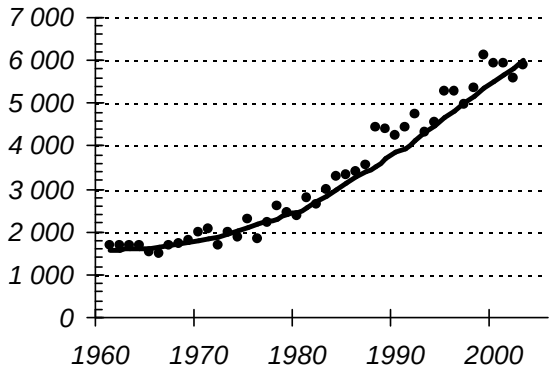


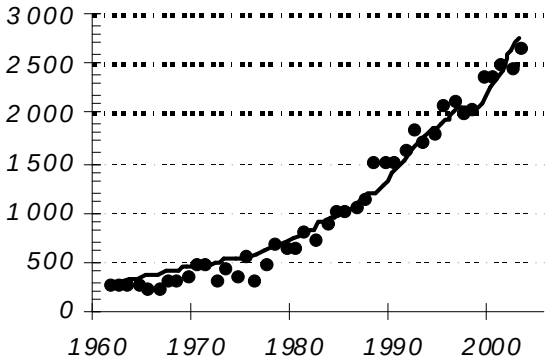
FSU





ASIA-Ch
(Asia without China)





❼ Annual R/U balances of food biomass reconstituted (1961-2003) ...or simulated

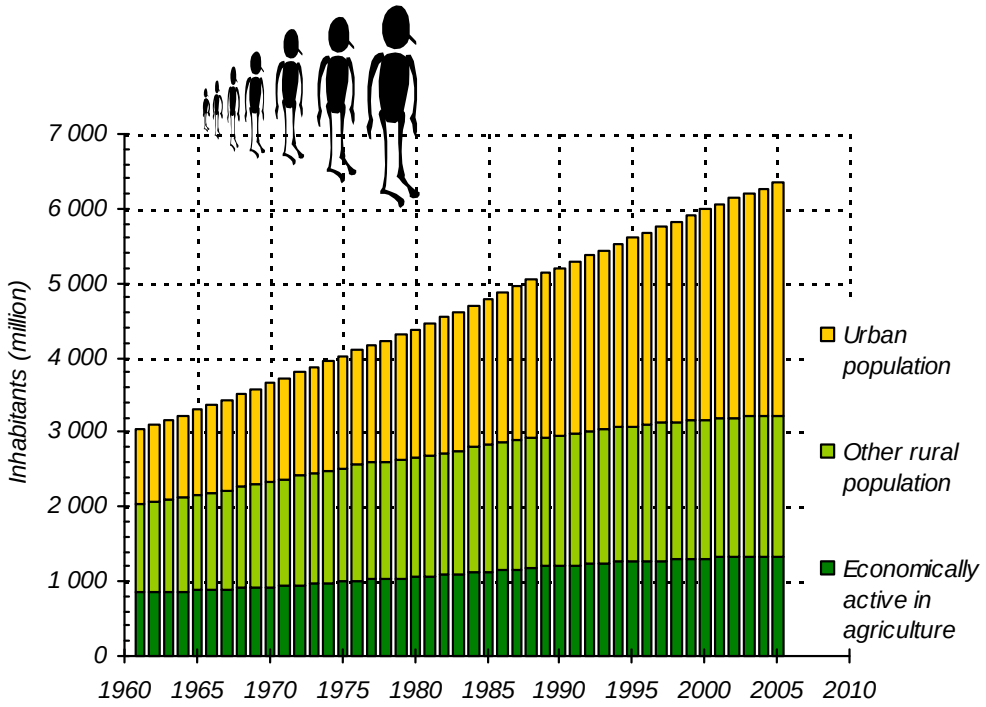
Part II

From past trends to scenarios

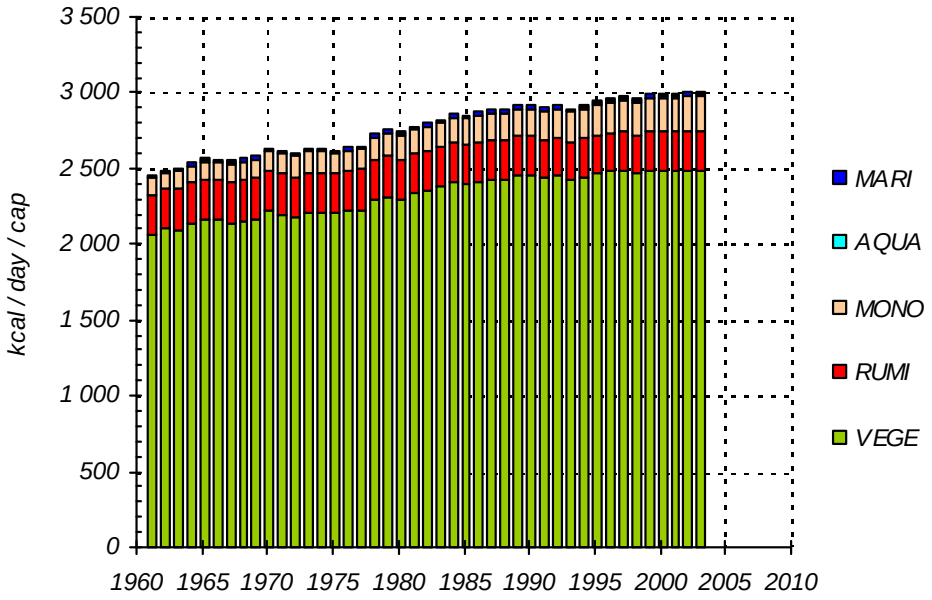
A 1961-2003 brief overview of the world food economy through Agribiom eyes…

❶ From average world increases…

- *The population doubled*



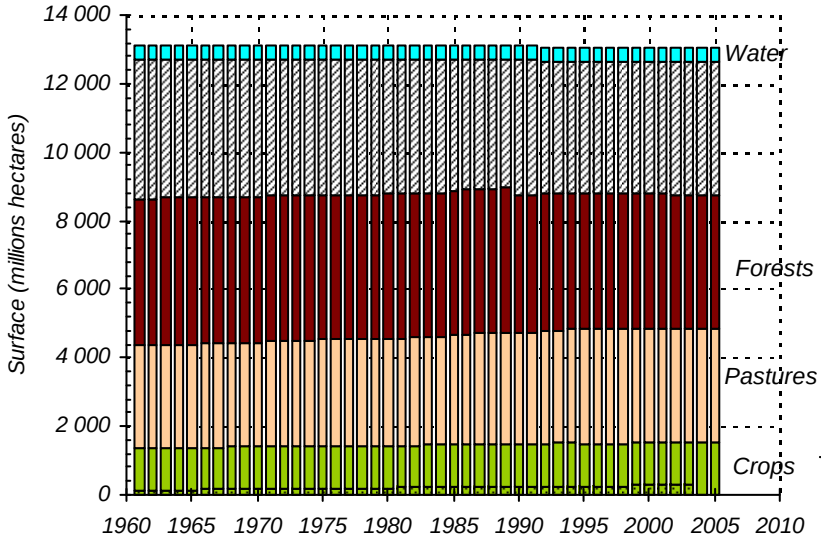
- *The per-capita food availability increased too…*



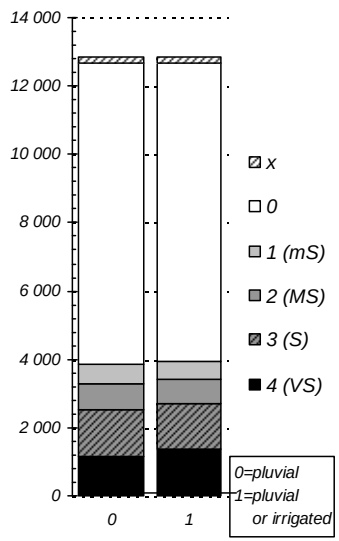
Source: own calculations using FAO data

On the resources side:

- *Agricultural area ↗*
  - *Pastures : + 11%*
  - *Crops : + 13%*

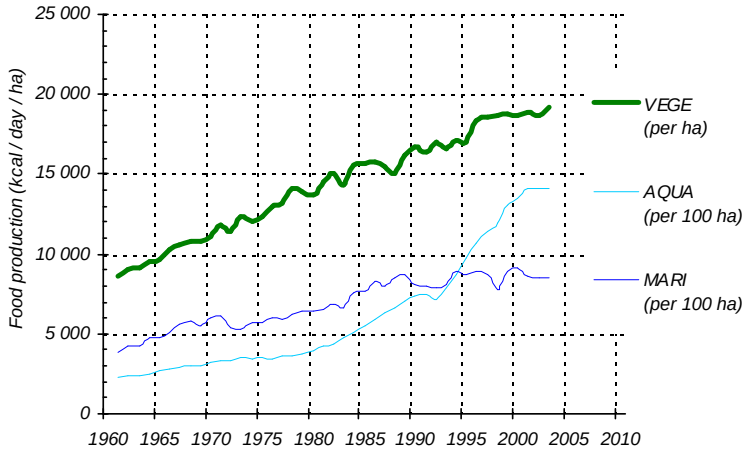


Up to (potential)



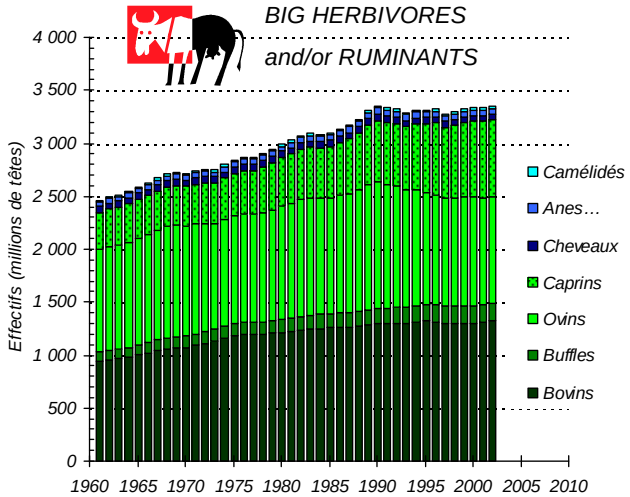
Source : data from Fischer et al.

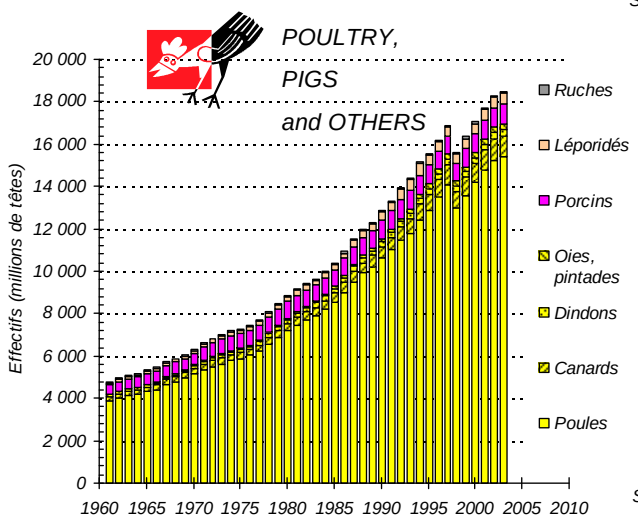
- *Land and labour productivities ↗*
  - *Veg calories / cultivated ha : + 123%*
  - *Veg calories / farmer : + 53%*



Source : own calculations using FAO data

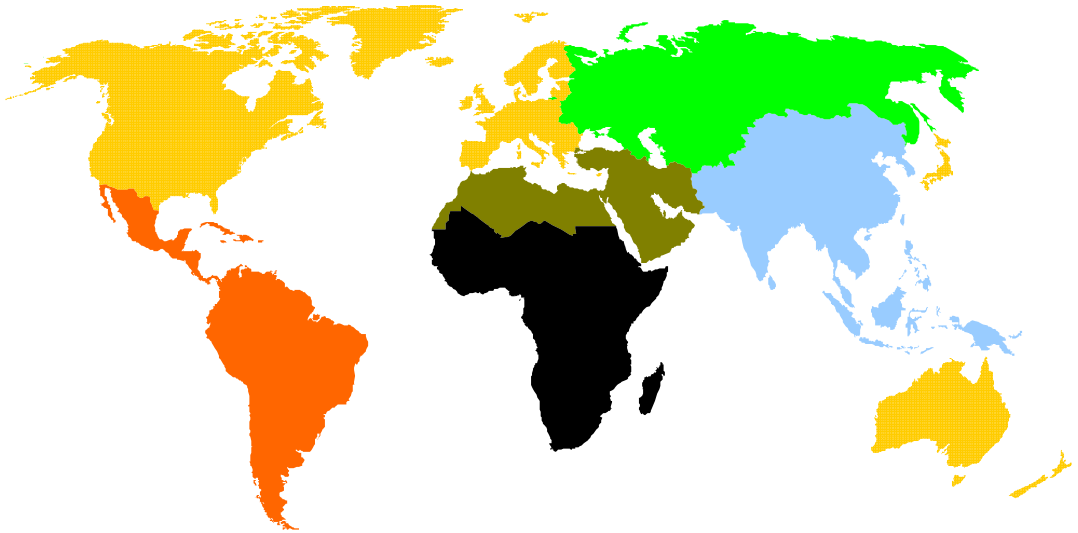
- *Livestock ↗*





Source : data from FAO

❷ ...to regional disparities

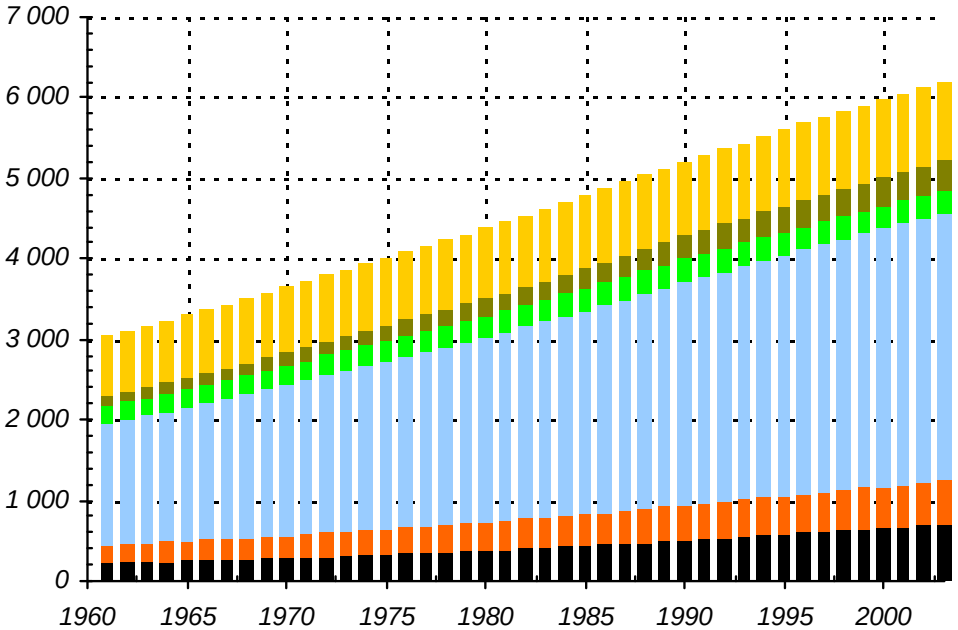


The 6 MEA regions

- *OECD = Oecd-1990*
- *MENA = Middle East & North Africa*
- *FSU = Former USSR*
- *ASIA = Asia*
- *LAM = Latin America & the Caribbean*
- *SSA = Sub-Saharan Africa*

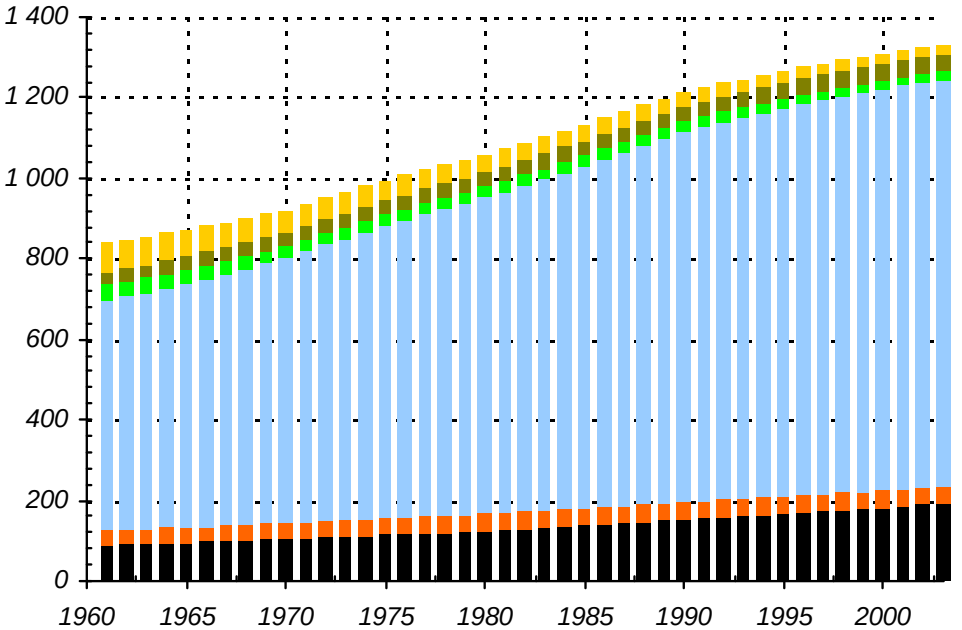
Human populations

Inhabitants (million)



Farmers : highly and increasingly concentrated in Asia and Africa

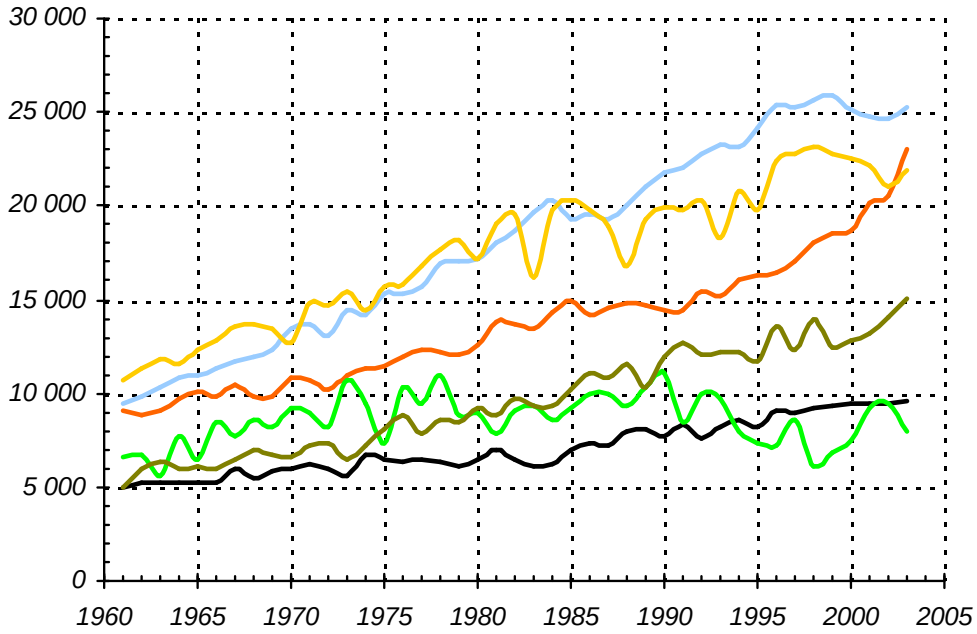
Active agricultural workers (million)



Source: data from FAO

Highest land productivity in ASIA

Vegetal kcal / day / cultivated hectare

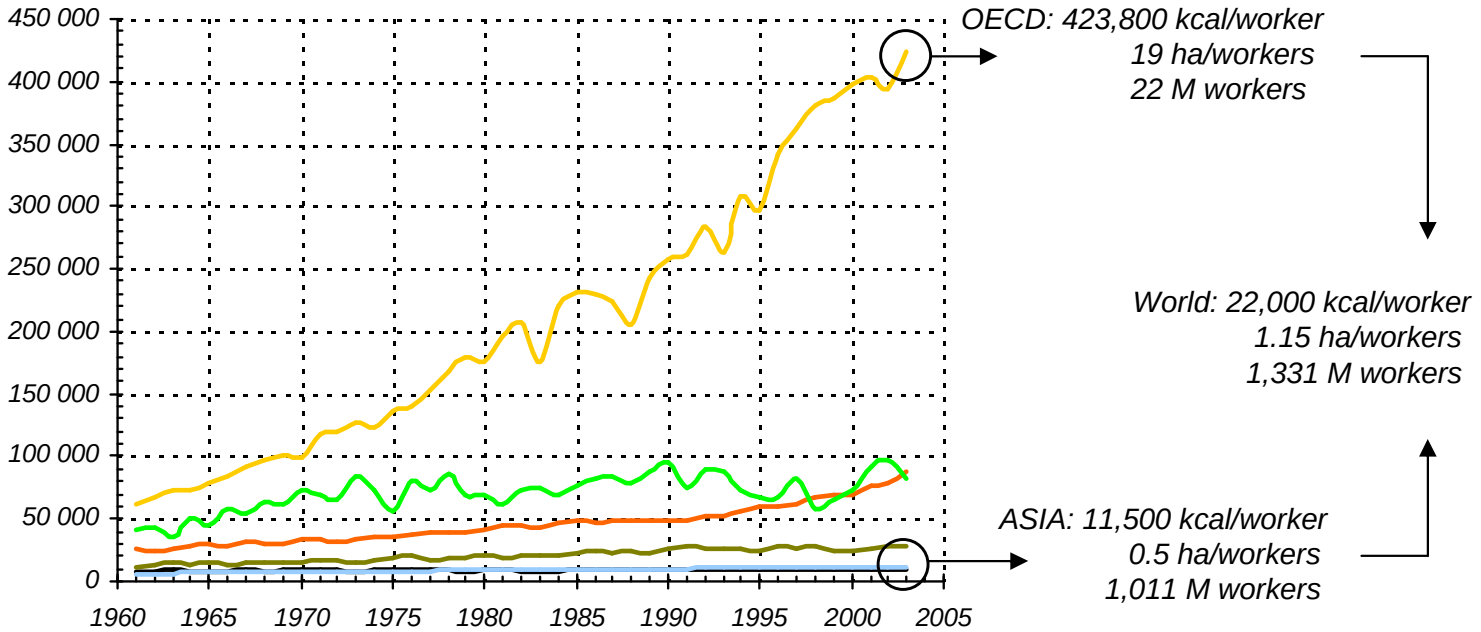


Source: own calculations using FAO data

Note : 10 000 kcal =
~ 2.4 kg of soybean
~ 2.8 kg of rice milled
~ 2.9 kg of pea
~ 3.0 kg of wheat
~ 15.0 kg of potato
~ 58.8 kg of tomato

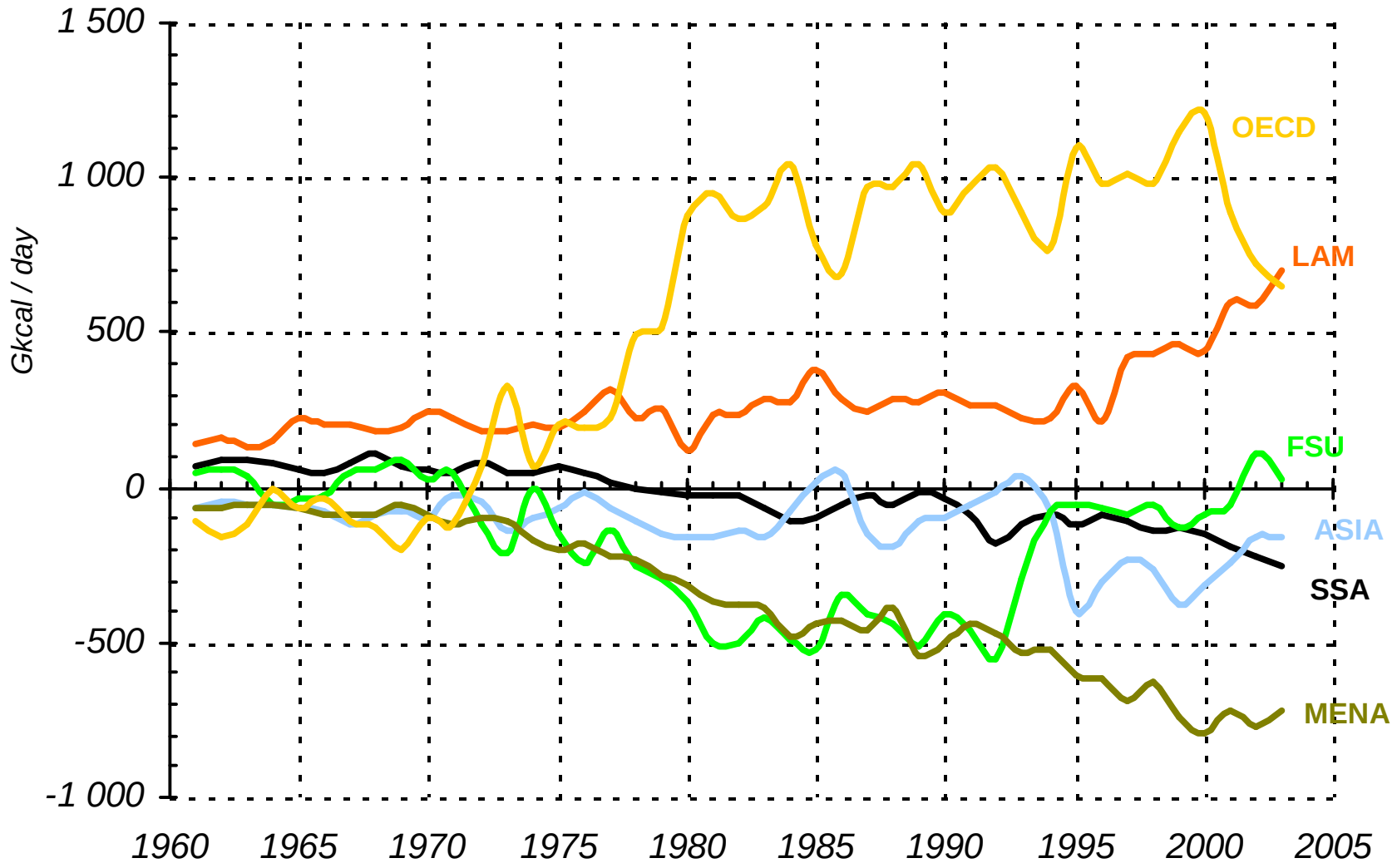
A labour productivity boom in OECD

Vegetal kcal / day / agricultural worker



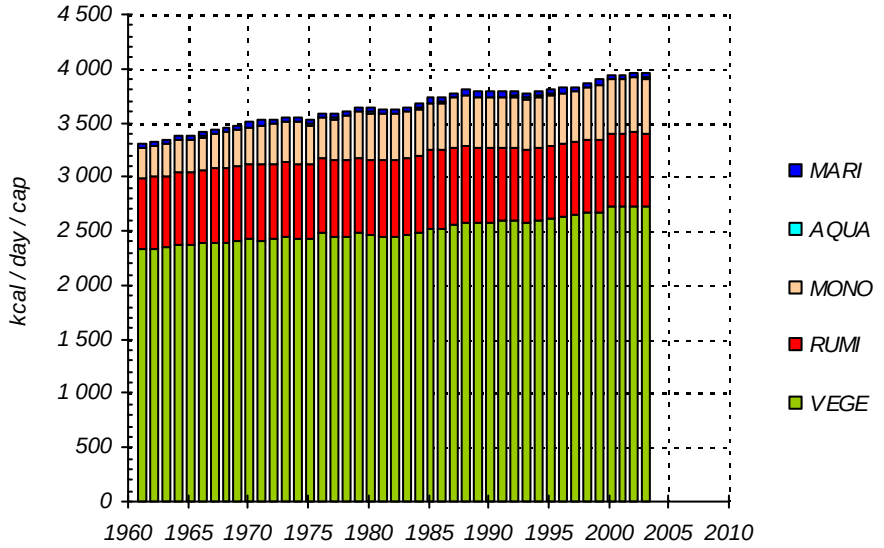
A boom of food trade to clear surpluses and fill in deficits

Net balance of vegetal food trade
(Exports – Imports)



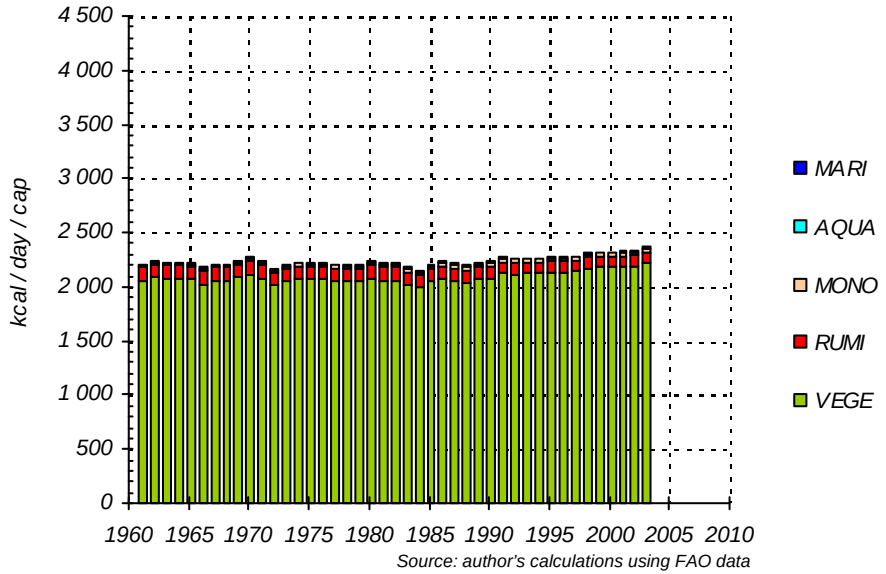
Source: own calculations using FAO data

But still very large disparities in per-capita food availabilities



OECD

- *Animal proteins :*
  71 g / day on 125 (60%)
- *Animal fats :*
  89 g / day on 165 (55%)



Source: author's calculations using FAO data

Sub-Saharan Africa

- *Animal proteins :*
  12 on 60 g / day (20%)
- *Animal fats :*
  10 on 48 g / jour (20%)

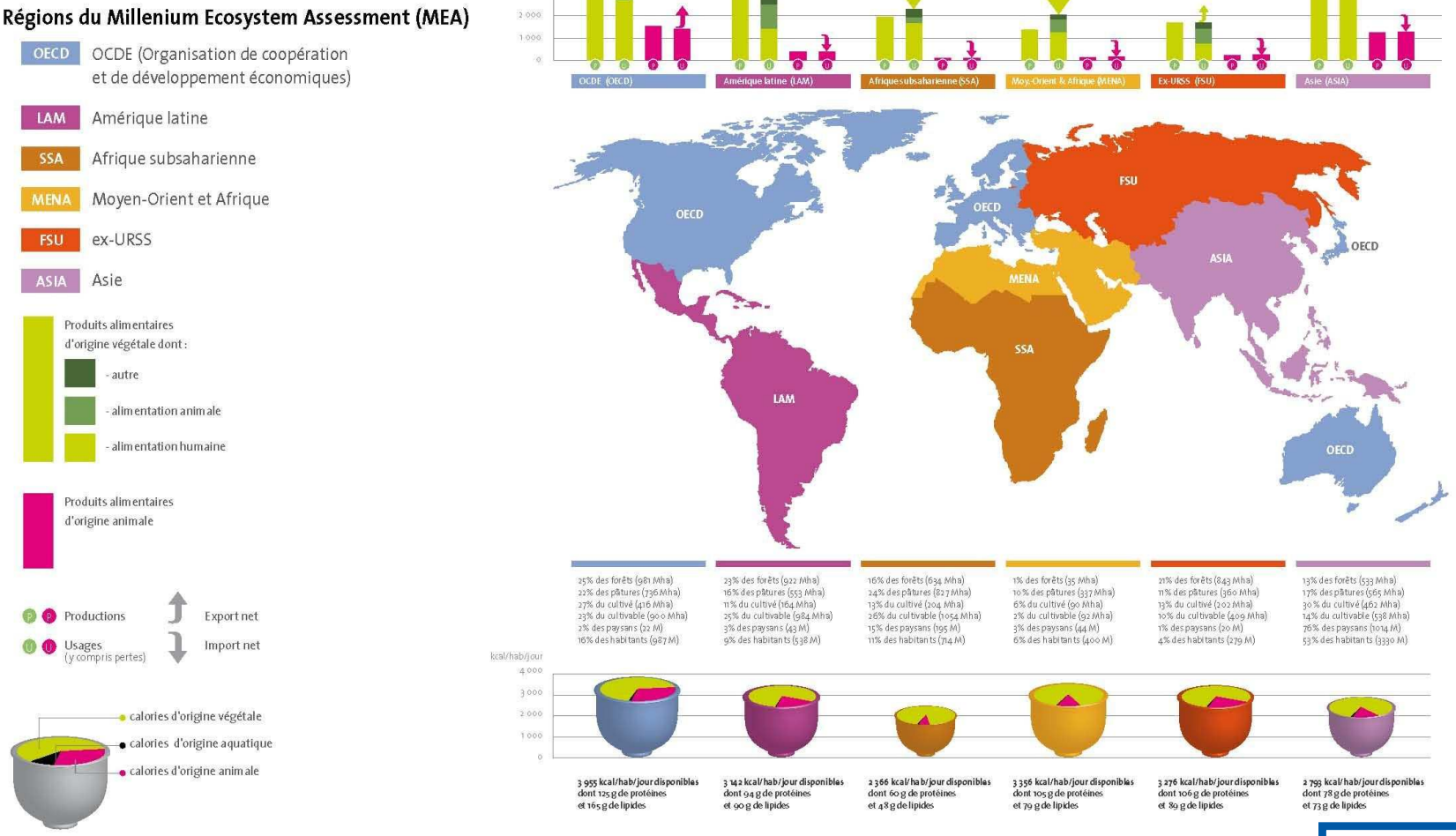
❸ Towards which new «equilibrium» in 2050 ?

Resources, productions, trade and uses of food biomasses (2003)

http://www.cirad.fr/upload/en/communique/Cirad-Inra-Agrimonde-GB.pdf

Ressources, production, échanges et consommation alimentaire en 2003 par grandes régions du monde

Sources : B. Dorin/Cirad, d'après données FAO



Scenarios, hypotheses, collective debates… (2050)

Agribiom simulations

Part III

Scenarios and challenges for feeding the world in 2050

First explorations by Agrimonde : the "AGO" and "AG1" worlds…

❶ Towards which new «equilibrium» in 2050 with…

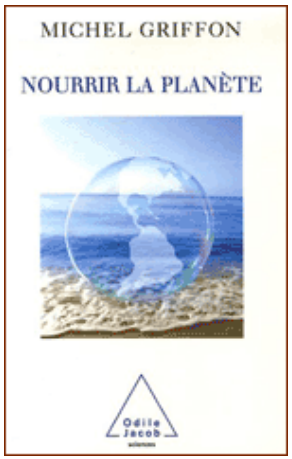
- +/- *population growth* *(7-11 billions inhabitants in 2050)* ?
- +/- *incomes, incomes distribution and population migrations*
  (regional opportunities of decent incomes, self-subsistence…) ?
- +/- *change in food diets* *(vegetal/animal, macro/micro nutrients…)* ?
- +/- *demand in non-food products* *(bio-energies, bio-materials...)* ?
- +/- *economic liberalization and trust in international trade*
  ("sovereignty" in cereals / other basic vegetal foodstuffs / feed for animal productions / animal foodstuffs…) ?
- +/- *environmental regulations* *(forests, greenhouse gases, biodiversity…)* ?
- +/- *important crisis on present yield boosts* *(fossil fuels, water, pesticides, phosphates…)* ?
- +/- *climate change*
- *…/…*

❷ The “AGO” and “AG1” worlds

Two scenarios “reprocessed”

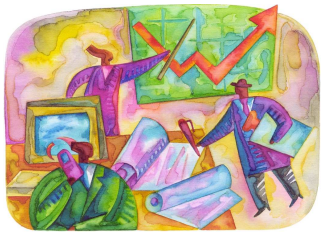
The Doubly Green Revolution scenario

Source: Griffon M., 2006. Nourrir la planète. Pour une Révolution doublement verte, Odile Jacob, Paris



The Green Revolution, which was introduced on a world scale after World War II, made it easy to ignore the threat of hunger. But the Green Revolution also encouraged overpopulation; it ravaged the environment in many places; it created inequalities in the sharing of the planet’s wealth, and these inequalities have made the threats we must face in the coming decades even greater than those the world had to confront in the early twentieth century.

Agrimonde platform



The “Agrimonde 1” scenario (AG1)

The “Agrimonde GO” scenario (AGO)

The Millennium Ecosystem Assessment scenarios

Source: MEA, 2005. Ecosystems and Human Well-being: Scenarios, The Millennium Ecosystem Assessment, Washington DC.

Global Orchestration
A globally connected society that focuses on global trade and economic liberalization and takes a reactive approach to ecosystem problems but that also takes strong steps to reduce poverty and inequality and to invest in public goods such as infrastructure and education. Economic growth in this scenario is the highest of the four scenarios, while it is assumed to have the lowest population in 2050.

Techno-Garden
A globally connected world relying strongly on environmentally sound technology, using highly managed, often engineered, ecosystems to deliver ecosystem services, and taking a proactive approach to the management of ecosystems in an effort to avoid problems. Economic growth is relatively high and accelerates, while population in 2050 is in the midrange of the scenarios.

Order from Strength
A regionalized and fragmented world, concerned with security and protection, emphasizing primarily regional markets, paying little attention to public goods, and taking a reactive approach to ecosystem problems. Economic growth rates are the lowest of the scenarios (particularly low in developing countries) and decrease with time, while population growth is the highest.

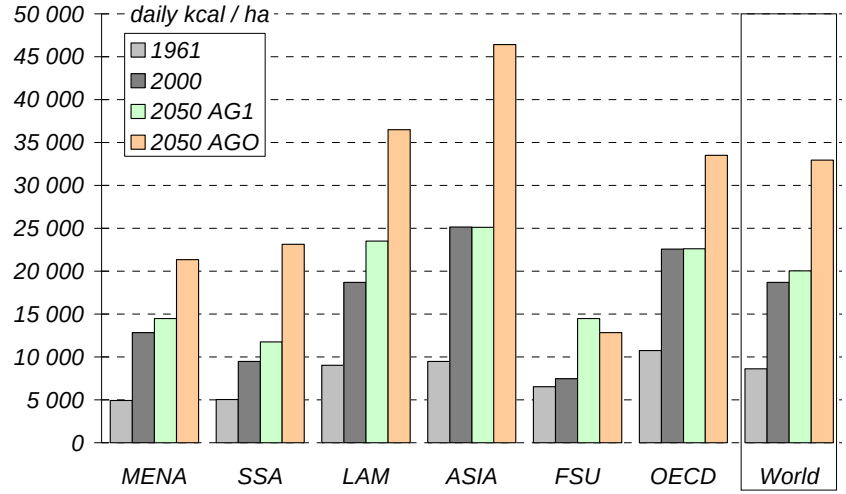
Adapting Mosaic
Regional watershed-scale ecosystems are the focus of political and economic activity. Local institutions are strengthened and local ecosystem management strategies are common; societies develop a strongly proactive approach to the management of ecosystems. Economic growth rates are somewhat low initially but increase with time, and population in 2050 is nearly as high as in Order from Strength.

Globalization
Reactivity
Proactivity
Regionalization

Main quantitative assumptions

		2003	2050 - AG1	2050 - AGO
Uses	Population	6.2 Gcap	8.8 (+42%)	8.8 (+42%)
	Human food	3,000 kcal/day/cap 17% Non-Veg	**3,000** **17%** Non-Veg	**3,590** (+19%) **23%** Non-Veg
	Other uses	~14,440 Gkcal/day	Feed (Agribiom) + seed (3%) + waste (max 4%) + other (max 5%)	Feed (Agribiom) + seed (3%) + waste (max 4%) + other (max 5%)
Ressources	Food yields	~19,190 kcal/day/ha	~20,030 (**+4%**)	~32,940 (**+75%**)
	Crop land - for N-Food	~1,530 Mha neg.	~2,105 (**+38%**) 224 Mha	~1,860 (**+21%**) 217 Mha
	Pastures	~3,330 Mha	~2,845 (**–14%**)	~3,585 (**+8%**)
	Forest	~3,905 Mha	no change	no change

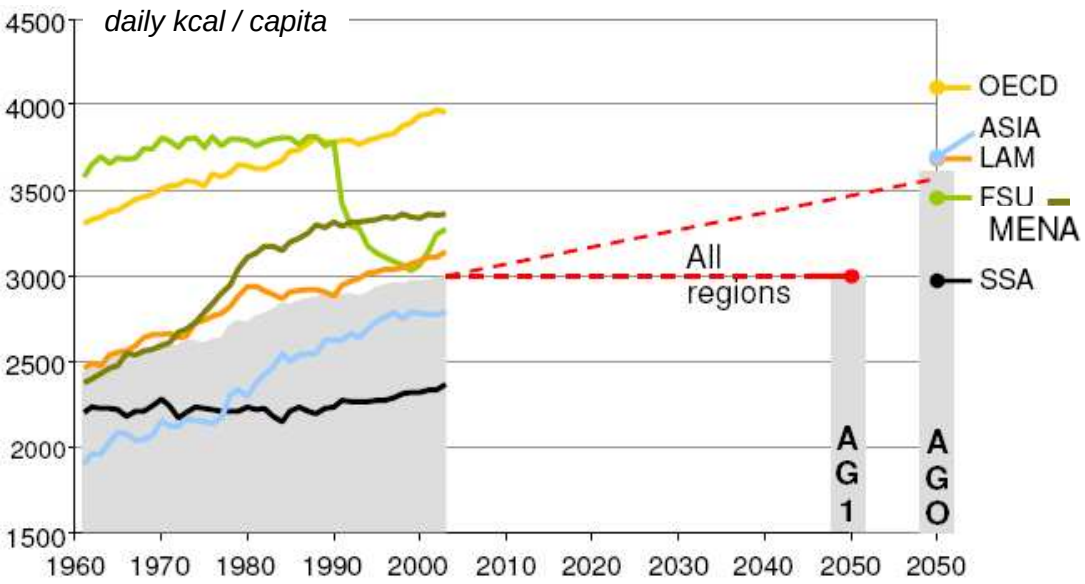
Trade : *h01 : trade of plant food only (i.e. no trade of animal foodstuffs or by-products)*
h02 : import of animal foodstuffs instead of import of plant feed

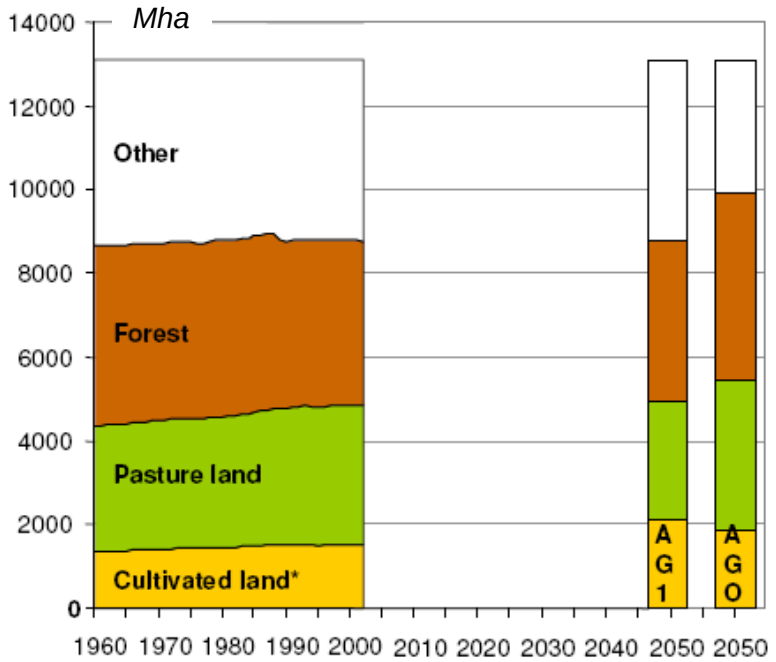


Yield

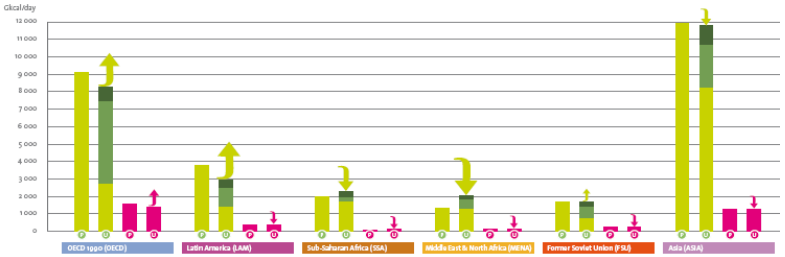
Land

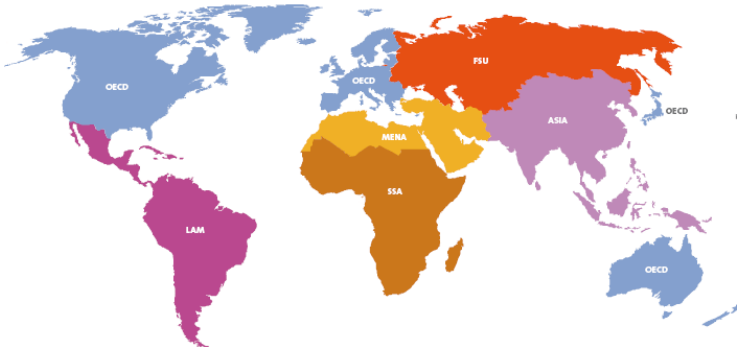
Food



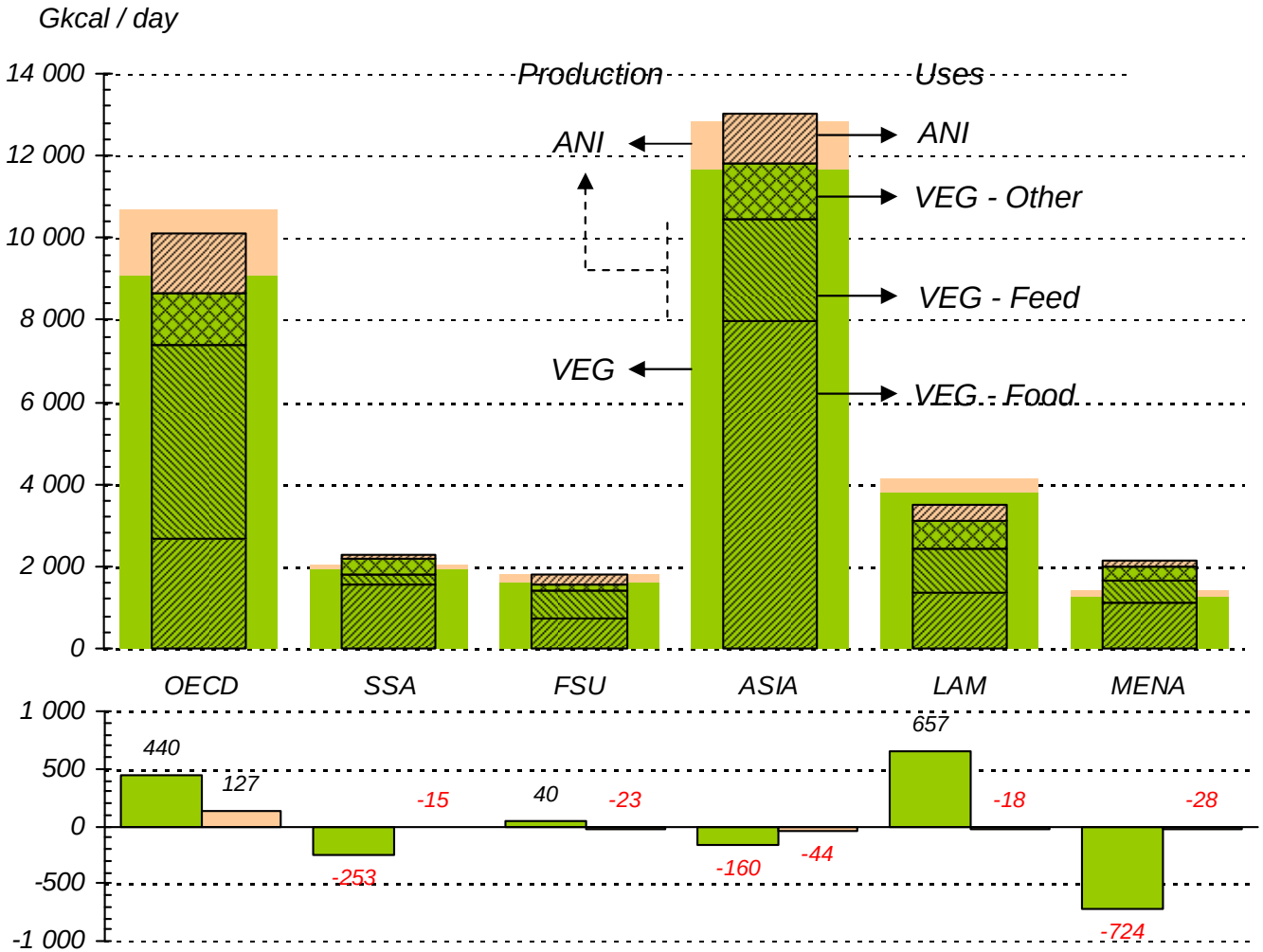


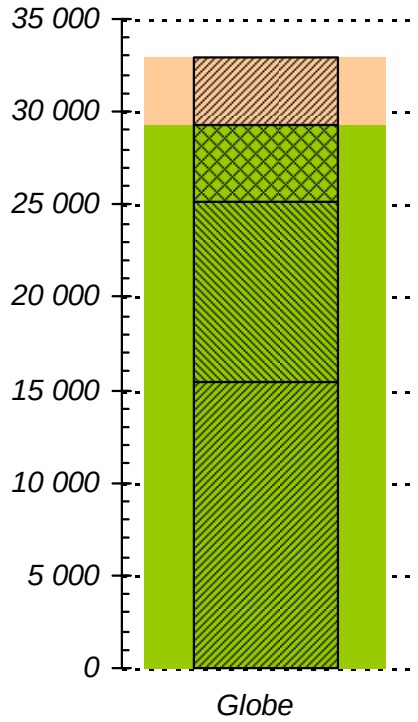
❸ Two new hypothetical equilibriums for 2050…





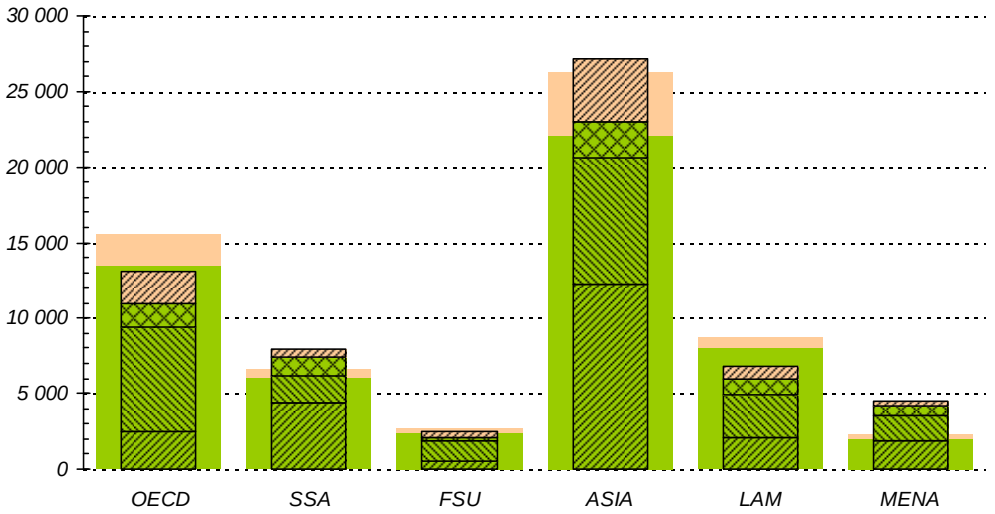
- *Base 2003*

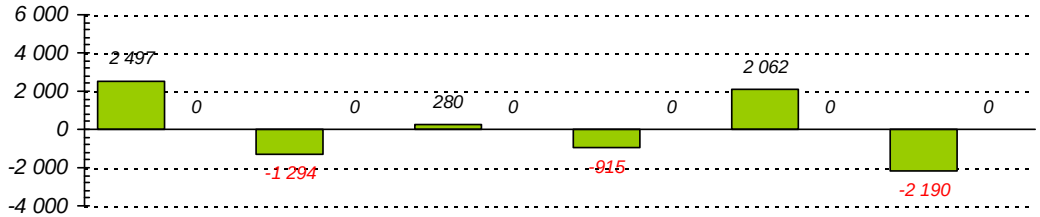


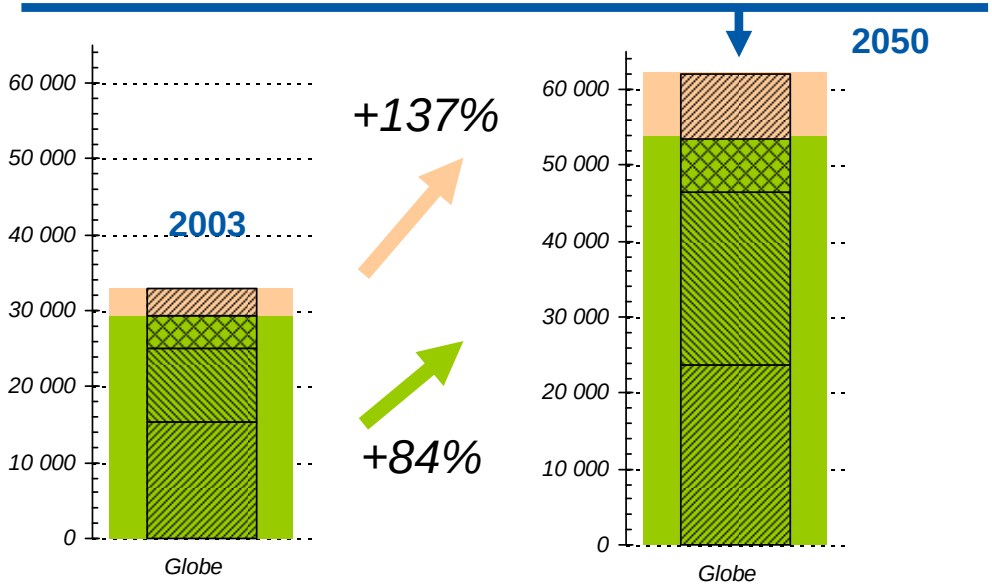


Scenario 2050 - AGO

AGO.h01

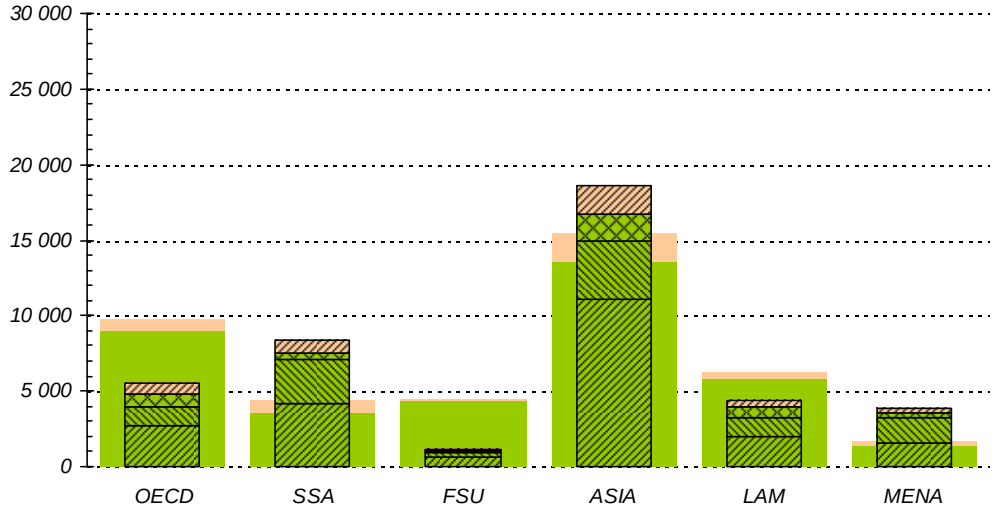


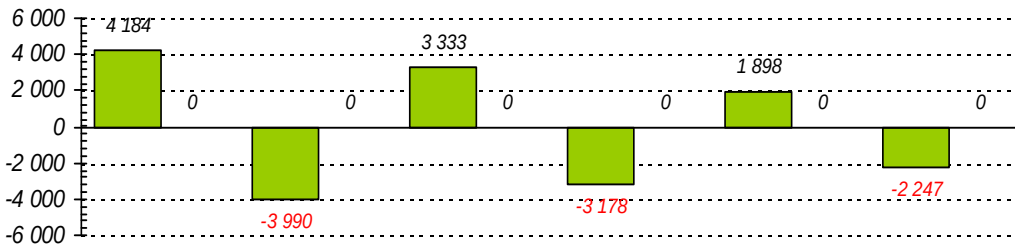


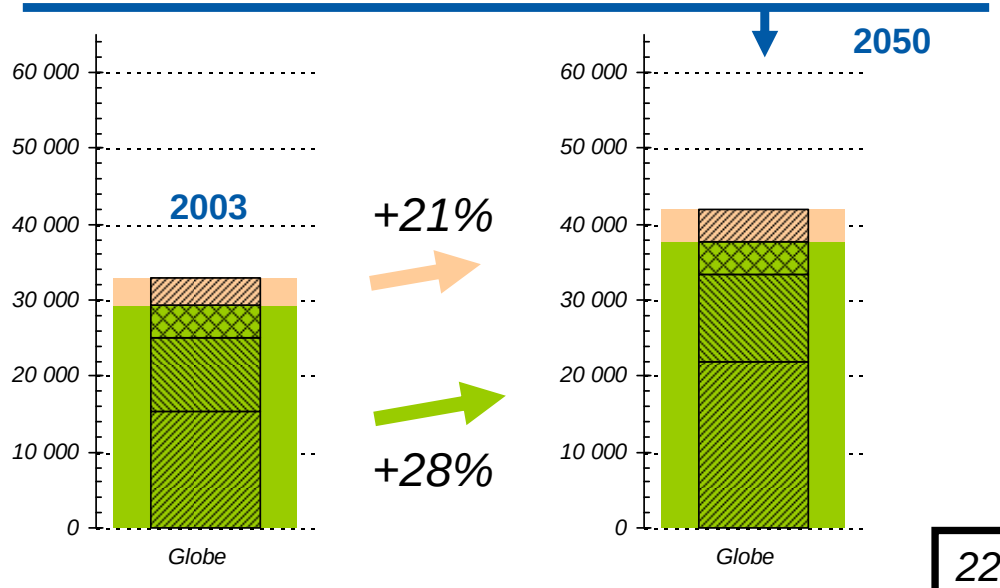


Scenario 2050 - AG1

AG1.h01







❹ Possible narratives for each scenario

Scenario principles → quantitative assumptions → quantitative consistency → qualitative assumptions → complete scenario

	Agrimonde GO	Agrimonde 1
Growth, developt & migrations	Economic growth in LDC based on agricultural development	
	High level of global growth Acceleration of urbanization	Global growth based on deving countries Stabilization of urbanization
Regulations and governance	Massive north south transfers	
	Trade liberalization	UNOFS : price distortions, volatility, temporary exceptions, envt protection multi-functionality
AKST-D	Massive public and private investment	
	Continuing the same technological pathway	Scientific innovation for ecological intensification : ▪ specific / generic ▪ interactive, mutualization
Energy	Massive investments	
	Rapid growth of energy demand Energy efficiency Biofuels	Demand management Energy efficiency, renewable energies Decentralized production Farm autonomy

❺ Main lessons from 2 scenarios (3 open questions)

The planet can feed properly 9 billion people in 2050
However…

(1) The contents of each person's plate (quantity + ingredients + presentation) will be a key driver for:
- solving important human health problems (from under-nutrition to obesity)
- preserving some ecosystem services (climate/disease/flood regulations, pollination…)
- saving some agricultural inputs (water, fossil fuels, fertilizers, pesticides…)
- reducing post-harvest losses and food wastes
- opening larger opportunities for non-food productions (bio-energies, biomaterials…)
- promoting a diversity of production systems, landscapes and rural livelihoods

➡ *What does a "sustainable food system" mean (content / tradeoffs / pathway) ?*

(2) Food trade can secure some regional food needs and avoid huge migrations, provided the net-deficit regions/populations can:
- pay for their food imports (local opportunities of incomes?)
- rely on a fair, transparent & LT secured international trade regulation system
...enhancing small farmers incomes & environment-friendly

➡ *How to design such a international trade system ? a UNOFS ?*

(3) Preserving or improving agricultural yields calls for breakthroughs:

- *Need for much less polluting & less dangerous techniques (for workers, flora, fauna…)*
  based on: - much better exploitation of ecosystem services (pollination, IP…)
  - new technologies (ITC, genetics, monitoring…)
  - scientific & local knowledge (social learning processes)

- *"Ecological intensification" might emerge as an interesting option for sustainable biomass production and for food security of poor farming families, provided institutional and technological lock-in situations can be overcome*

- *Need to reframe the usual yield/area dilemma & the production/protection divide*
  - city/countryside <=> urban & peri-urban agriculture…
  - forest/agriculture <=> agro-forestry, agro-ecology…
  - "high yield - land sparing" (man outside the nature)
  <=> "wildlife-friendly farming" (man into the nature) *(Green & al, 2004)*
  - …

→ *Which renewed technological patterns ?*
- how to think outside conventional boundaries ?
- which organizational/institutional breakthroughs ?

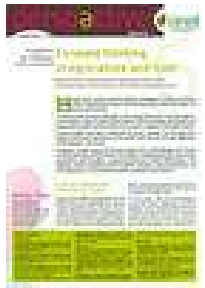
To follow up…

- *Need to debate food and agriculture scenarios at various regional levels* *(…with various stakeholders)*
- *Need to better simulate* *(with Agribiom and other quantitative tools)*
  - *induced consumptions of fossil fuel and water*
  - *GHG emissions/sinks (C, CO_2, CH_4, N_2O…)*
  - *regional employments / incomes / migrations*
  - *…/… and biodiversity ?*
- *Need to involve a large set of actors, stakeholders …and academic disciplines into food production, food security, food safety and food quality issues!*

FI4IAR-CTA seminar "Thinking forwards: assessments, projections, foresights"

⇒ *Paris (Jan. 2010), Wageningen (Feb. 2010), GCARD (March 2010)*

⇒ *A dialogue between the authors of 10 long-term assessment/outlook works (MEA, IAASTD, WDR-2008, RuralStruc, WFM-Fao, IMPACT-Ifpri, Mediterra-2008, SCAR-Foresight, UK-Foresight, Agrimonde…)*

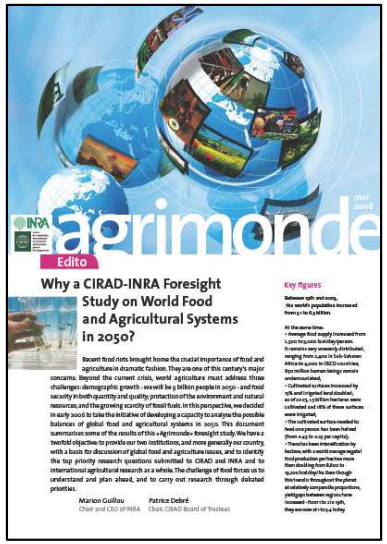


…/…

Agrimonde materials available on the web & elsewhere

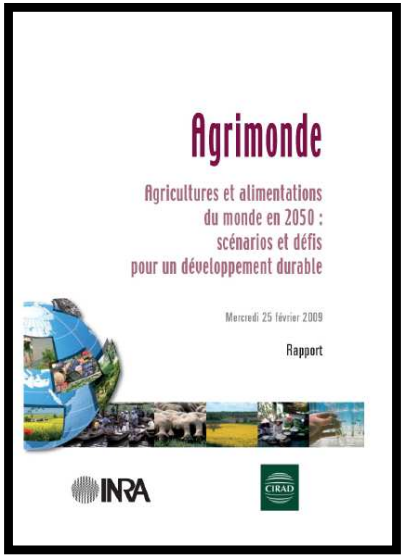
http://www.inra.fr/l_institut/prospective/agrimonde
http://www.cirad.fr/actualites/toutes-les-actualites/articles/2009/science/resultats-de-la-prospective-agrimonde

Preliminary results
8 pages brochure
May 2008



FR & EN

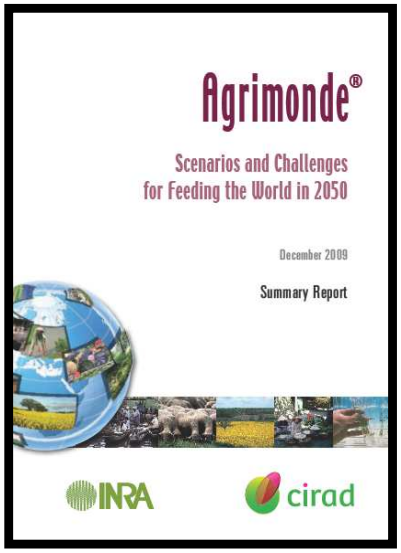
REPORT
200 pages
Feb. 2009



Coming soon…

BOOKS *(FR & EN)*
2010

SUMMARY REPORT
32 pages
June 2009

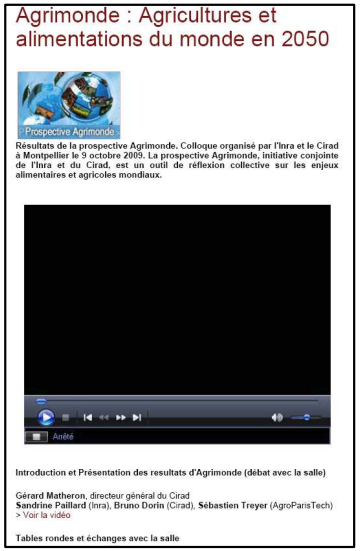


FR & EN
Updated versions
December 2009

BROCHURE
12 pages
Oct 2009

FR only

VIDEOS
Presentations & debates
Feb-Oct 2009



FR only

Thank you for your attention

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ROUDART Laurence
SALLE Christian
TOUREAU Valérie
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